Envelopment analysis for global response to novel 2019 coronavirus-SARS-COV-2 (COVID-19)

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Abstract

Communities are constantly seeking to manage the damages which are caused by crises. In this regard, health centers have become the most expensive unit of the health system as they provide quick and timely health care services to reduce the effects of unexpected accidents. So, their planning and preparation should be considered as an important part of strategic health policies. The purpose of this study is to investigate performance evaluation techniques for health units, which is helpful for WHO to identify the capabilities of crisis management and the limitations of world health units. This study evaluates the performance of the world health systems dealing with Corona-virus based on parametric and nonparametric statistical techniques according to "Population, GPD Per Capita, Total Recovered, Total Cases, and Total Deaths". This descriptive cross-sectional study is performed on the World Population Review, Worldometer, WHO data of Covid-19 from 1 March -11 April 2020. Based on the results, the efficient and inefficient health system units are identified. The results of this study show that 52 medical centers have not performed efficiently. The average efficiency of inefficient units is 0.30. On this basis, most of the studied countries do not operate efficiently due to the lack of optimal use of resources. Ineffective health system units call for greater attention of WHO in promoting health culture during the crisis management of common viruses. Therefore, there is a capacity to improve efficiency by 70%. By conducting this research, in addition to the introduction of functional patterns to the top health managers, it is possible to plan more accurately to develop the capacity of health care services and save resources.

Keywords: health system unit, coronavirus, DEA, COVID-19, WHO.

1. Introduction

Humans have always been fighting against microorganisms for centuries. With global warming and the increasing number of travelers, both the newly emerging potential viral diseases and resistant bacterial infection, are always a vital concern and the measures taken to control and prevent these infections have become more important. Disastrous phenomenon of a global virus, in addition to life disabilities, brings economic and psychological damages (Özel Gaziosmanpaşa Hastanesi, 2014).

Each crisis affects the world in a different way. Therefore, countries are constantly seeking for solutions to control and manage the damages of the crisis. Crisis management is defined as systematic efforts to prevent the occurrence of crises as well as effective management of the crises when they occur. Crises always have a negative impact on public health and the well-being of the affected population, while health care is a survival factor. Therefore, the health system units are fragile due to the lack of planning to deal with such crises. In this regard, health centers, as the forefront of treatment, have become the most expensive unit of the health system by fundraising the most medical funds of the countries (Green et al., 2003). WHO's concurrent management of health capabilities, promoting health culture and monitoring are essential for achieving health stability and controlling critical viruses worldwide.

A health system will be economically viable when it provides the right services and, most importantly, to provide it in a useful and relevant manner. Since focusing and investing in health and medical services increases the productivity of the health system, the allocation of adequate resources and optimal utilization of resources in this system is of great importance (Zervopoulos et al., 2016). The main purpose of this study is to model the performance of efficient health system units to reduce the mortality and morbidity of the Coronavirus crisis.

An efficient performance evaluation system can affect the survival of organizations. Health centers, as one of the main organizations providing health services and because of their significant role in people's health (Masiye, 2007), feel the need to evaluate their performance and improve their efficiency more than other organizations. One of the significant issues in the developed countries is the required resources by the health sector, which is supplied by a part of GDP and governmental expenses (Wordsworth et al., 2005). Therefore, increasing the efficiency and productivity, optimal allocation of resources, improving the quality of services, cost control and considering appropriate policies will be vitally important.

On the one hand, increasing advances in medical science, technology and healthcare has created obstacles in providing health facilities and services. Additionally, changing lifestyles, cultural and social structure, changing patterns of diseases and medical needs of people, and accelerated population growth have made the situation even more complex. On the other hand, the optimal utilization of material and human resources for the efficient production and delivery of health services requires the knowledge of economic regulations (Andes et al., 2002). Improving economic efficiency enables the health system to use the available resources optimally and to promote justice and equality (Lee et al., 2015).

This highlights the need for more effective use of available resources by utilizing resource allocation patterns and enhancing the efficiency of health centers (Kazemi, 2009). Given the importance of the subject and the lack of coordination standards in many units of the health system, one of the most effective evaluation tools is data envelopment analysis. Employing this method, the units are not compared to a predetermined standard level. However, the efficiency of the units is measured with respect to the efficiency of the other units.

Assessing the efficiency of healthcare systems is a difficult process, which often encounters methodological problems. Starting with the health status of the citizens, which influences the productivity level, the welfare level or socio-economic stability, increasing

the efficiency of healthcare services is a standing objective, which becomes highly important and necessary to those countries that have a low or medium human development index. On the other hand, the states with a high development index are obliged to assure a high level of efficiency and quality of their health services. For the past years, society has made impressive progress in ensuring better health services, especially those services channeled towards improving maternal and infant health or towards increasing life expectancy. Nevertheless, an increase in the indicators at national levels did not result in the improvement of the indicators for the groups of citizens predisposed to certain maladies, while the progress in some cases stagnated and the overall results were not significant. In this context, the efficiency of human, material and financial resources involved in the health sectors becomes a relevant topic both for scientists and for health policy makers (Asandului et al., 2014). Suggest that in order to achieve the same health outcomes, national healthcare systems need to use public and private health resources more effectively and efficiently. By assessing the efficiency of countries' healthcare systems and health services through international comparison, effectiveness and efficiency can be ensured within these systems (Top et al., 2020).

Today, in the medical sciences and health systems, epidemiological knowledge has a special place as a field which studies the factors affecting the distribution and abundance of diseases in societies. Epidemiology is the study of the distribution and determinants of health-related conditions or events in certain populations and the use of this study to fight against the health problems. The study of disease abundance and the study of disease distribution are common topics in epidemiology."

The statistical tests used in this study are divided into two groups: parametric and non-parametric. Parametric tests analyze the data at the level of spatial and relative scales, whose minimum statistical index is the "mean". Non-parametric tests, however, analyze the data at the level of nominal and rank scale, whose statistical index is "mode" and "median".

This problem highlights the need for a more efficient use of available resources by applying resource allocation patterns and increasing the efficiency of medical center management. Regarding the great impact of health services on the efficiency of the world's health system, and especially in critical situations, performance analysis can be an important step in the continuous improvement of performance of health system units by providing the possibility of comparison and ranking. Given the importance of the issue and the fact that there is no standard of coordination in many units of the health system, one of the effective tools for evaluation is data envelopment analysis. Using this method, the studied units are not compared with a predetermined standard level and the efficiency of the units is measured according to the efficiency of other units. This performance evaluation technique provides cost-cutting solutions by providing accurate scientific approaches to the World Health Organization's decision-making process. It can also be used as an effective and efficient health assessment strategy in the field of health evaluation.

2. Literature review

Several studies of performance evaluation and Infectious Disease are as follows:

- Kontodimopoulos et al. (2006) used data envelopment analysis (DEA) to evaluate the technical efficiency of a number of hospitals and medical facilities in Greece. In their study, they considered human and medical facilities as input indicators and patients and health services as output indicators. Finally, they evaluated the efficiency of the hospitals using Data Envelopment Analysis method.
- Weng et al. (2009) presented an extended DEA model which included a new benchmark filtering measure to identify the decision making units (DMUs) with the best performance. Moreover, window analysis was employed over multiple time periods to consider the time dependent nature of hospital data. The Malmquist method was also employed to complement the proposed approach to verify the temporal productivity performance of DMUs. The results indicated that the proposed model can generate benchmarks which consistently perform well over multiple time periods.
- Yawe, Bruno (2010) measured the technical efficiency of 25 district referral hospitals from three regions of Uganda over the 1999-2003 period. He employed a super-efficiency Data Envelopment Analysis model. The results of the standard data envelopment analysis models represented the existence of different degrees of technical and scale inefficiency in Uganda’s district referral hospitals. When super-efficiency models were executed, hospitals could be ranked and categorized into four groups: strongly super-efficient; super-efficient; efficient and inefficient.
- Chuang et al. (2011) evaluated the hospital operational efficiency for more appropriate resource allocation and cost effectiveness. Several DEA-based models were first compared, and the DEA-artificial neural network (ANN) model was known as more capable than the DEA and DEA-assurance region (AR) models for recognizing the best-performing hospital. The classification and regression tree (CART) efficiency model was consequently utilized to extract rules for improving resource allocation of medical institutions.

- Fanti et al. (2013) proposed a model based on a three-level strategy to design at the tactical level. A real case study on the Emergency Cardiology Department of the General Hospital of Bari (Italy) showed the efficiency and accuracy of the proposed method.
- Rahimi et al. (2014) tried to identify the major indicators for the evaluation of hospital performance. The obtained results showed that evaluators were mostly interested in the use of quantitative indicators in the evaluation of hospital performance. In addition, a wide range of indicators was used to evaluate the quality of hospital services. It was recommended that hospital managers select a combination of quantitative and qualitative indicators for accurate monitoring of their hospital performance.
- Asandului et al. (2014) evaluated the efficiency of public healthcare systems in Europe by utilizing a nonparametric technique such as DEA. Three output variables were chosen: life expectancy at birth, health adjusted life expectancy, infant mortality rate and three input variables: number of doctors, number of hospital beds and public health expenditures as a percentage of GDP. The findings demonstrated that there are a number of both developed and developing countries on the efficiency frontier, while the great majority of the countries in the sample are not efficient.
- Kyoung Won Cho et al. (2015) evaluated the performance of the newly developed information system (IS) implemented on July 1 2014, at three public hospitals in Korea. User satisfaction scores were according to twelve key performance indicators of six IS success factors based on the DeLone and McLean IS. Success Model was employed to evaluate IS performance before and after the newly developed system. The results suggested that hospitals should not only focus on systems and information quality. Rather, they should continuously improve their service quality to improve the user satisfaction and, eventually, reach the full potential of IS performance.
- June & Choi (2016) examined the MERS-CoV infection status of clinical nurses and evaluated the infection control using MERS-CoV press release data. As a result, One to six nurses per hospital in total of 8 health care facilities were infected by MERS-CoV. They mainly had short clinical careers and were unaware of infection possibility. The personal and organizational infection control levels that nurses perceive were low and the relationship between two levels was statistically significant. They concluded to promote the health protection and infectious disease management competency of nurses, it is necessary to prepare the institutional system for controlling infectious disease.
- Dickmann et al. (2016) indicated that there is still a need to clarify and integrate risk communication concepts into a more standardized practice and improve risk communication and health, particularly among disadvantaged populations. To address these challenges, the European Centre for Disease Prevention and Control (ECDC) gathered a group of risk communication experts to review and integrate the current approaches and to emerge concepts in the development of a training curriculum. This curriculum expresses a new approach in risk communication and it is beyond the information transmission. In pilot training, this approach was tested both in the topics and methods. This article introduced the new conceptual approach for the risk communication capacity building which emerges from this process, presented the pilot training approach, and shared the results of the course evaluation.
- Liang et al. (2017) evaluated the research performance by DEA and provided the relevant development measures of medical subjects at Peking University People's Hospital. This paper studied the indicators for the evaluation of medical systems. The output-based DEA was applied for the evaluation to reflect the performance of medical systems. The analysis of the evaluation provides the management department of the hospital with shreds of evidence and references to make policies for medical activities.
- Wand & Guo (2018) studied domestic and overseas studies on the efficiency of TCP

for chronic diseases shreds of evidence and found the key action links in three aspects: functional training of multiple-joint guided by consciousness, relieving psychological risk factors, improving respiratory and digestive function, blood and lymph circulation through respiratory training, and regulation of nerve, metabolic, and immune system. Finally, they concluded how to apply TCP in chronic disease management, and the practice and evaluation approach should be evaluated academically.

- Maria Di Mascolo et al. (2018) developed an integrated approach which combines simulation and risk analysis in the sterilization service, in order to consider the impact of risks in the evaluation of the performance of the system. The approach includes developing an operating model of the sterilization service which describes the feature of the system. This system is subject to a multitude of risks, which can disrupt its operation. To consider these risks, an analysis was done. This model was simulated using a SIM. JS library and JavaScript. The simulation brought the possibility of evaluating the system performance under different behavior modes (normal mode, degraded, reconfigured).
- Gansek et al. (2019) presented semantic data interoperability and they summarized its added value. They also analyzed the technical foundation supporting of the standardized healthcare system interoperability which enabled them to move to e-health. Additionally, they reviewed the current usage of those foundational standards and advocated for their uptake by all infectious disease-related actors. Such semantic data is one of the technical building blocks that support emerging digital medicine, e-health, and P4-medicine (predictive, preventive, personalized, and participatory).
- In Eggers (2019) study, it was proven that hand washing with PVP-I-based antiseptics is suitable for the decontamination of skin, while PVP-I mouthwashes and gargles hugely reduce viral load in the oral cavity and the oropharynx. The significance of PVP-I was emphasized by the list of necessary medicines in World Health Organization. Moreover, high potency for virucidal activity was observed against viruses of important global concern, including hepatitis A and influenza, as well as the Middle-East Respiratory Syndrome and Sudden Acute Respiratory Syndrome Corona-viruses. In addition to its various applications in antimicrobial control, wide accessibility all over the globe, and astonishing safety and tolerability profile, PVP-I provides an affordable, potent, and broadly available antiseptic option.
- Moons et al. (2019) measured the logistics efficiency of internal hospital supply chains and more specifically in the operating theatre since it is among the most critical resources for a hospital. In the operating theatre, the requested items must be available at the right time, right place, right condition and the lowest cost possible. Moreover, we will also survey the literature on multi-criteria decision-making (MCDM) techniques. It enables researchers to build a performance measurement framework and prioritize multiple performance metrics since a diverse group of stakeholders with conflicting interests is included in the internal operating room supply chain.
- Bai et al. (2020) assessed the performance of the United States (U.S.) and Chinese radiologists in differentiating COVID-19 from viral pneumonia on chest CT. A total of 205 patients with positive Respiratory Pathogen Panel (RPP) for viral pneumonia and CT findings consistent with or highly suspicious for pneumonia by original radiology interpretation within 7 days of each other were identified from Rhode Island Hospital in Providence, RI. Three Chinese radiologists blindly reviewed all chest CTs (n=424) to differentiate COVID-19 from viral pneumonia. A sample of 58 age-matched cases was randomly chosen and evaluated by 4 U.S. radiologists in a similar fashion. Different CT features were recorded and compared between the two groups.
- Top et al. (2020) measured the healthcare system efficiency of 36 African countries and to compare efficiency levels between countries. Data envelopment analysis (DEA) was

employed to evaluate efficiency. The input variables employed within the scope of DEA consisted of the proportion of total health expenditures in the gross domestic product (HE); the number of physicians (PHY), nurses (NUR) and hospital beds (BN) per 1000 people; the unemployment rate (UN); and the Gini coefficient (Gini). The study's output variables were life expectancy at birth and 1/(infant mortality rate). After the implementation of DEA, the variables affecting the performance of national healthcare systems were determined using a Tobit regression model.
Table 1 summarizes a number of research records on performance evaluation of health centers.

Table 1. Research gap

Researchers	Research tools	Research achievements	
		Performance evaluation	Infection Diseases/ COVID-19
Kontodimopoulos et al. (2006)	DEA	✓	
Weng et al. (2009)	DEA	✓	
Yawe, Bruno (2010)	DEA	✓	
Chuang et al. (2011)	DEA	✓	
Fanti et al. (2013)	three-level strategy	✓	
Rahimi et al. (2014)			
Asandului et al.(2014)	DEA	✓	
Kyoung Won Cho et al. (2015)	IS	✓	
June & Choi (2016)			✓
Dickmann et al. (2016)			
Liang et al. (2017)	DEA	✓	
Wand & Guo (2018)	TCP		✓
Maria Di Mascolo et al. (2018)	simulation and risk analysis	✓	
Gansek et al. (2019)			
Eggers (2019)			✓
Moons et al. (2019)	MCDM	✓	
Bai et al. (2020)		✓	✓
Top et al. (2020)	DEA	✓	

Lack of research to evaluate the performance of health system units during crisis highlights the need for the effective use of available resources by utilizing resource allocation patterns and enhancing the efficiency of health centers. Improving economic efficiency enables the health system to use the available resources optimally and to promote justice and equality.

3. Research method

The present study is a descriptive-analytical and cross-sectional study which has been conducted in 2020 to evaluate the effectiveness of the world health system against Coronavirus using parametric and non-parametric statistical tests. The research population is health system units of the countries presented in the Worldometer report. The study has been conducted from 1st March to 11th of April 2020 in 71 countries with at least 42 days of

Coronavirus involvement, according to Table 1. The time window was defined as 42 days according to the COVID-19 Incubation period for 14 days after exposure.

Evaluation indices vary in different research of the health systems. The index has a significant role in the success of research analysis. Most researchers have used common indices of "Total Recovered, Total Deaths, Total Cases, Day of Infection" in evaluating the performance of health system units (Mohammadkarim et al., 2011) (Nikjoo et al., 2013) (Zaboli et al., 2011) (Basu et al., 2010) (Nasiripour et al., 2010) (Garcia-Lacalle et al., 2010)

(Tavakoli et al., 2015). The importance of the "Population, GDP Per Capita" indices in evaluating the performance of the healthcare system are also observed in other research (Kok Fong and SiewHwa, 2018). The importance of these two indices is also emphasized in the authentic documents such as EDDC, 2 March 2020 and EUROPEAN COMMISSION, 13 March 2020. Some documents confirm the risk of transmission of the virus through the tourist community (WHO, 17 March 2020). Selected indices allow for a comprehensive evaluation of the Corona crisis management of health system units. In order to evaluate the performance of each unit of the health system comprehensively, other indices are needed to be studied. These indices include social and cultural contexts, rate of underlying diseases, medical staff qualifications, quality of care, modern and advanced equipment, medical staff knowledge and training, health center budgeting and self-management. These are not consistent with the scope of this study but they are recommended for a more comprehensive evaluation.

In this study, the input variables are:

- "Population, GDP Per Capita" from World Population Review
- "Total Cases" from Worldometer
- "Day of Infection" from World Health Organization

And, the output is:

- "Total Recovered, Total Deaths » from World Health Organization

In order to determine the highest efficiency ratio and to involve the inputs and outputs of other decision-making units in determining the optimal weights, the BCC output-based model is proposed. The constant return to scale can be applied if only health system units operate at an optimal level. But different issues such as restrictions, medical facilities, country strategies, etc. cause health system units not to operate at the optimal level. The performance analysis of health system units can be considered as a long-term goal at constant-scale efficiency, and as a short-term goal at variable-scale efficiency for inefficient health system units. On the other hand, undeclared or zero values cannot be applied to the DEA, and the health system performance of these units is not considered. After data collection and entry into Excel software, DEAFrontier software was used for data analysis and evaluation. In order to implement the output-based BCC model, the basic Model (1) is proposed.

The evidence from analyses of cases in China shows that the disease is mild (i.e. non-pneumonia or mild pneumonia) in about 80% of cases; most cases recover (European Center for Disease Prevention and Control, 2020). This rate is given in the corona-virus case and the mathematical model. The death rate has an undesirable nature, so it is reversed.

Max φ (1)
St:

$$\varphi y_{ro} - \sum_{j=1}^{n} \lambda_j \left(\frac{1}{0.2 y_{1j}} + 0.8 y_{2j}\right) \le 0 \qquad , r = 1, \dots, s$$

$$\sum_{j=1}^{n} \lambda_j x_{ij} \le x_{io} \qquad , i = 1, \dots, m$$

$$\sum_{j=1}^{n} \lambda_j = 1$$

$\lambda_j \ge 0, \forall_j$, φ free variable

Where the convexity constraint ($\sum^{n}_{j=1}\lambda_j = 1$) makes it possible to compare decision-making units with each other. Also, o is the index of decision-maker unit. y_{ij} and x_{ij} are, respectively, the values of the output r and input i for the unit (unit o) and, the output rand input i for the unit j. Moreover, s is the number of scenarios, m is the number of inputs and n is the number of units. Since solving dual problems or envelopment model requires less operation due to fewer constraints, the output-based BCC envelopment model is used in this study.

4. Findings

This paper evaluates the performance of countries' health systems with non-zero numbers. According to the results of BCC model in DEAFrontier software, in the indicators of "Total Cases, Total Recovered, Day of Infection, Total Deaths", are studied with DEA techniques to specify the efficient and inefficient health units internationally. The results are shown in Table 6.

Epidemiology is the study of the distribution and determinants of health states or events in specific populations and the application of this study for fighting against health problems. Popular topics of epidemiology are the study of disease abundance and the study of disease distribution. The abundance of disease is the frequency of diseases in society and the measurement of disease rates and proportions. Disease distribution is the study of diseases at different times, places, and individuals, known as descriptive studies. The ultimate goal of epidemiology is to prevent diseases and promote the community health. The application of epidemiology is to describe the volume of health problems and the frequency of diseases in societies and how they are distributed. Obtaining basic information for the planning, implementation and evaluation of disease prevention, control and treatment services and prioritizing them are the other applications of epidemiological study, which is done by parametric statistical tests in Section 4-1 to 4-4 of this study.

Table 2. Input and output data (World Health Organization, Worldbank, Worldometer, World Population Review)

No.	Country	Day of Infection (Report 28 March)	Total Cases 1 Mar 2020	Total Cases 11 Apr 2020	International tourism number of arrivals Most Recent Value (Thousands) 2018	2019 Population	GDP Per Capita	Total Deaths Y_1	Total Recovered Y_2
1	**Afghanistan**	23-Feb	1	555	50	38,041,754	531	18	32
2	**Algeria**	24-Feb	1	1,761	2,657.00	43,053,054	4,403	256	405
3	**Armenia**	29-Feb	1	967	1,652.00	2,957,731	4,680	13	173
4	**Australia**	24-Jan	25	6,292	9,246.00	25,203,198	58,097	56	3,265

5	**Austria**	24-Feb	10	13,767	30,816.00	8,955,102	53,482	337	6,604
6	**Azerbaijan**	27-Feb	3	991	2,830.00	10,047,718	11,403	10	159
7	**Bahrain**	23-Feb	40	1,016	12,045.00	1,641,172	23,923	6	551
8	**Belarus**	27-Feb	1	2,226	1,221.00	9,452,411	6,737	23	172
9	**Belgium**	03-Feb	1	28,018	9,119.00	11,539,328	47,782	3,346	5,986
10	**Brazil**	24-Feb	2	19,943	6,621.00	211,049,527	9,703	1,074	173
11	**Cambodia**	26-Jan	1	120	4,832.00	16,486,542	1,753	-	75
12	**Canada**	24-Jan	19	22,148	21,134.00	37,411,047	48,553	569	6,013
13	**China**	10-Jan	79968	81,953	62,900.00	1,433,783,686	10,747	3,339	77,525
14	**Croatia**	24-Feb	7	1,534	-	4,130,304	15,733	21	323
15	**Denmark**	26-Feb	3	5,996	12,749.00	5,771,876	62,937	260	1,955
16	**Dominican Republic**	29-Feb	2,620	7,161	6,569.00	10,738,958	8,339	126	98
17	**Ecuador**	28-Feb	7,161	1,794	1,878.00	17,373,662	6,106	297	368
18	**Egypt**	13-Feb	1,794	1,304	11,196.00	100,388,073	3,238	135	384
19	**Estonia**	26-Feb	1,304	555	3,234.00	1,325,648	25,054	24	93

Table 2. Input and output data– Continued

No.	Country	Day of Infection (Report 28 March)	Total Cases 1 Mar 2020	Total Cases 11 Apr 2020	International tourism number of arrivals Most Recent Value (Thousands) 2018	2019 Population	GDP Per Capita	Total Deaths Y_1	Total Recovered Y_2
20	**Finland**	28-Jan	2	2,905	3,224.00	5,532,156	52,203	49	300
21	**France**	23-Jan	100	124,869	89,322.00	65,129,728	44,062	13,197	24,932
22	**Georgia**	25-Feb	3	234	3,518.00	3,996,765	4,735	3	56
23	**Germany**	26-Jan	57	122,530	38,881.00	83,517,045	49,617	2,736	53,913
24	**Greece**	25-Feb	3	2,011	30,123.00	10,473,455	22,114	92	269
25	**Iceland**	27-Feb	1	1,675	2,343.80	339,031	78,598	7	751
26	**India**	29-Jan	3	7,876	17,423.00	1,366,417,754	2,361	249	774
27	**Indonesia**	01-Mar	2	3,842	15,810.00	270,625,568	4,420	327	286
28	**Iran**	18-Feb	593	70,029	7,295.00	82,913,906	5,902	4,357	41,947
29	**Iraq**	21-Feb	13	1,279	892	39,309,783	6,139	70	550
30	**Ireland**	28-Feb	1	8,089	10,926.00	4,882,495	82,058	287	25
31	**Israel**	20-Feb	7	10,525	4,121.00	8,519,377	46,671	96	1,258
32	**Italy**	29-Jan	1128	147,577	61,567.20	60,550,075	34,575	18,849	30,455
33	**Japan**	14-Jan	239	6,005	31,192.00	126,860,301	43,450	99	762
34	**Kuwait**	23-Feb	45	1,154	8,508.00	4,207,083	33,485	1	133
35	**Latvia**	01-Mar	1	630	1,946.00	1,906,743	20,200	3	16
36	**Lebanon**	20-Feb	2	619	1,964.00	6,855,713	8,881	20	76
37	**Lithuania**	27-Feb	1	1,026	1,419.00	2,759,627	21,159	23	54
38	**Luxembourg**	28-Feb	1	3,223	1,018.00	615,729	117,725	54	500
39	**Malaysia**	24-Jan	24	4,530	25,832.00	31,949,777	12,420	73	1,995
40	**Mexico**	27-Feb	2	3,844	23,802.00	127,575,529	10,065	233	633

Table 2. Input and output data– Continued

No.	Country	Day of Infection (Report 28 March)	Total Cases 1 Mar 2020	Total Cases 11 Apr 2020	International tourism number of arrivals Most Recent Value (Thousands) 2018	2019 Population	GDP Per Capita	Total Deaths Y_1	Total Recovered Y_2
41	**Monaco**	27-Feb	1	90	347	38,964	164,823	1	5
42	**Morocco**	01-Mar	1	1,527	12,289.00	36,471,769	3,496	110	141
43	**Nepal**	23-Jan	1	9	744	28,608,710	1,134	-	1
44	**Netherlands**	26-Feb	7	24,413	18,780.00	17,097,130	55,730	2,643	250
45	**New Zealand**	27-Feb	1	1,312	10,961.00	4,783,063	46,647	4	422
46	**Nigeria**	27-Feb	1	305	1,977.00	200,963,599	2,407	7	58
47	**Macedonia**	25-Feb	1	760	387	2,083,459	6,576	34	41
48	**Norway**	25-Feb	15	6,360	5,688.00	5,378,857	80,908	114	32
49	**Oman**	23-Feb	6	546	2,975.00	4,974,986	16,480	3	109
50	**Pakistan**	25-Feb	4	4,892	818	216,565,318	1,279	77	762
51	**Philippines**	29-Jan	3	4,428	7,168.00	108,116,615	3,550	247	157
52	**Portugal**	01-Mar	2	15,987	16,186.00	10,226,187	24,509	470	266
53	**Qatar**	28-Feb	1	2,728	1,819.30	2,832,067	70,810	6	247
54	**Romania**	25-Feb	3	5,990	11,720.00	19,364,557	13,678	282	758
55	**Russia**	30-Jan	2	13,584	24,551	145,872,256	11,426	106	1,045
56	**S. Korea**	19-Jan	3736	10,480	15,347.00	51,225,308	34,024	211	7,243
57	**San Marino**	26-Feb	1	344	84	33,860	49,276	34	50
58	**Saudi Arabia**	01-Mar	1	4,033	15,334.00	34,268,528	22,694	52	720
59	**Senegal**	01-Mar	1	278	1,365.00	16,296,364	1,676	2	152
60	**Singapore**	22-Jan	102	2,108	14,673.00	5,804,337	66,983	7	492
61	**Spain**	30-Jan	45	161,852	82,773.00	46,736,776	32,020	16,353	59,109

Table 2. Input and output data– Continued

No.	Country	Day of Infection (Report 28 March)	Total Cases 1 Mar 2020	Total Cases 11 Apr 2020	International tourism number of arrivals Most Recent Value (Thousands) 2018	2019 Population	GDP Per Capita	Total Deaths Y_1	Total Recovered Y_2
62	**Sri Lanka**	26-Jan	1	198	5,608.00	21,323,733	4,200	7	54
63	**Sweden**	30-Jan	13	10,151	7,440.00	10,036,379	57,105	887	381
64	**Switzerland**	24-Feb	18	24,900	10,362.00	8,591,365	85,585	1,003	11,100
65	**Taiwan**	20-Jan	40	385	-	23,773,876	26,607	6	99
66	**Thailand**	12-Jan	42	2,518	38,178.00	69,625,582	7,843	35	1,135
67	**Tunisia**	01-Mar	1	671	8,299	11,694,719	2,974	25	43
68	**UAE**	28-Jan	19	3,360	21,286.00	9,770,529	45,411	16	418
69	**UK**	30-Jan	23	73,758	36,316.00	67,530,172	43,118	8,958	344
70	**USA**	20-Jan	62	503,177	79,745.92	329,064,917	67,063	18,761	27,314
71	**Vietnam**	22-Jan	16	258	15,498.00	96,462,106	2,901	-	144

Growth rate and compound average growth rate of Coronavirus patients

The purpose of this section is to evaluate the growth rate and compound average growth rate of Coronavirus patients in the world health system. The statistical data of the study are from the results of WHO report from 1st March to 11th April 2020. In this paper, Growth Rate (GR) and Compound Average Growth Rate (CAGR) are used to determine Coronavirus growth in health units. The computational form is as follows. GR and CAGR are calculated as follows:

$$GR = (\text{Present Value} - \text{Past Value}) / \text{Past Value} \tag{2}$$

$$CAGR = (EV / IV)^{1/n} - 1 \tag{3}$$

- EV = Ending Value
- IV = Initial Value
- n = Time period

The data were implemented in SPSS software and the results are presented in Table 3.

Table 3. GR and CAGR of Coronavirus patients worldwide (Worldometer)

No.	Country	Day of Infection	Total Cases (11 April 2020)	Total Cases (1 Mar 2020)	GR	CAGR
1	**Afghanistan**	48	555	1	554.00	0.14
2	**Algeria**	47	1761	1	1,760.00	0.17
3	**Armenia**	42	967	1	966.00	0.18
4	**Australia**	78	6,292	25	250.68	0.07
5	**Austria**	47	13,767	10	1,375.70	0.17
6	**Azerbaijan**	44	991	3	329.33	0.14
7	**Bahrain**	48	1016	40	24.40	0.07
8	**Belarus**	44	2226	1	2,225.00	0.19
9	**Belgium**	68	28,018	1	28,017.00	0.16
10	**Brazil**	47	19,943	2	9,970.50	0.22
11	**Cambodia**	76	120	1	119.00	0.07
12	**Canada**	78	22,148	19	1,164.68	0.09
13	**China**	92	81,953	79968	0.02	0.00
14	**Croatia**	47	1534	7	218.14	0.12
15	**Denmark**	45	5,996	3	1,997.67	0.18
16	**Dominican Republic**	42	2620	1	2,619.00	0.21
17	**Ecuador**	43	7,161	1	7,160.00	0.23
18	**Egypt**	58	1794	1	1,793.00	0.14
19	**Estonia**	45	1304	1	1,303.00	0.17
20	**Finland**	74	2,905	2	1,451.50	0.10
21	**France**	79	124,869	100	1,247.69	0.09
22	**Georgia**	46	234	3	77.00	0.10
23	**Germany**	76	122,530	57	2,148.65	0.11
24	**Greece**	46	2011	3	669.33	0.15
25	**Iceland**	44	1675	1	1,674.00	0.18

Table 3. GR and CAGR of Coronavirus patient worldwide (Worldometer) – Continued

No.	Country	Day of Infection	Total Cases (11 April 2020)	Total Cases (1 Mar 2020)	GR	CAGR
26	**India**	73	7876	3	2,624.33	0.11
27	**Indonesia**	41	3,842	2	1,920.00	0.20
28	**Iran**	53	70,029	593	117.09	0.09
29	**Iraq**	50	1279	13	97.38	0.10
30	**Ireland**	43	8,089	1	8,088.00	0.23
31	**Israel**	51	10,525	7	1,502.57	0.15
32	**Italy**	73	147,577	1128	129.83	0.07
33	**Japan**	88	6,005	239	24.13	0.04
34	**Kuwait**	48	1154	45	24.64	0.07
35	**Latvia**	41	630	1	629.00	0.17
36	**Lebanon**	51	619	2	308.50	0.12
37	**Lithuania**	44	1026	1	1,025.00	0.17
38	**Luxembourg**	43	3,223	1	3,222.00	0.21
39	**Malaysia**	78	4,530	24	187.75	0.07
40	**Mexico**	44	3844	2	1,921.00	0.19
41	**Monaco**	44	90	1	89.00	0.11
42	**Morocco**	41	1527	1	1,526.00	0.20
43	**Nepal**	79	9	1	8.00	0.03
44	**Netherlands**	45	24,413	7	3,486.57	0.20
45	**New Zealand**	44	1312	1	1,311.00	0.18
46	**Nigeria**	44	305	1	304.00	0.14
47	**Macedonia**	46	760	1	759.00	0.16
48	**Norway**	46	6,360	15	423.00	0.14
49	**Oman**	48	546	6	90.00	0.10
50	**Pakistan**	46	4,892	4	1,222.00	0.17
51	**Philippines**	73	4,428	3	1,475.00	0.11
52	**Portugal**	41	15,987	2	7,992.50	0.25
53	**Qatar**	43	2728	1	2,727.00	0.20
54	**Romania**	46	5,990	3	1,995.67	0.18
55	**Russia**	72	13,584	2	6,791.00	0.13
56	**S. Korea**	83	10,480	3736	1.81	0.01
57	**San Marino**	45	344	1	343.00	0.14
58	**Saudi Arabia**	41	4,033	1	4,032.00	0.22
59	**Senegal**	41	278	1	277.00	0.15
60	**Singapore**	80	2108	102	19.67	0.04
61	**Spain**	72	161,852	45	3,595.71	0.12
62	**Sri Lanka**	76	198	1	197.00	0.07
63	**Sweden**	72	10,151	13	779.85	0.10

Table 3. GR and CAGR of Coronavirus patient worldwide (Worldometer) – Continued

No.	Country	Day of Infection	Total Cases (11 April 2020)	Total Cases (1 Mar 2020)	GR	CAGR
64	**Switzerland**	47	24,900	18	1,382.33	0.17
65	**Taiwan**	82	385	40	8.63	0.03
66	**Thailand**	90	2,518	42	58.95	0.05
67	**Tunisia**	41	671	1	670.00	0.17
68	**UAE**	74	3360	19	175.84	0.07
69	**UK**	72	73,758	23	3,205.87	0.12
70	**USA**	82	503,177	62	8,114.76	0.12
71	**Vietnam**	80	258	16	15.13	0.04

The findings of Table 3 indicate that the GR infection rate is the highest in the countries of "Belgium, Brazil, USA, Ireland, Portugal, Ecuador, Russia, Saudi Arabia, Spain, Netherlands", and the CAGR infection rate is the highest in the countries "Portugal, Ireland, Ecuador, Saudi Arabia, Brazil, Luxembourg, Dominican Republic, Indonesia, Qatar, Netherlands". Indices such as GR help us to have a better view of the spread of Coronavirus and are a powerful tool to track the events. Figures 1 and 2 show the Distribution of GR and CAGR of the world health system units.

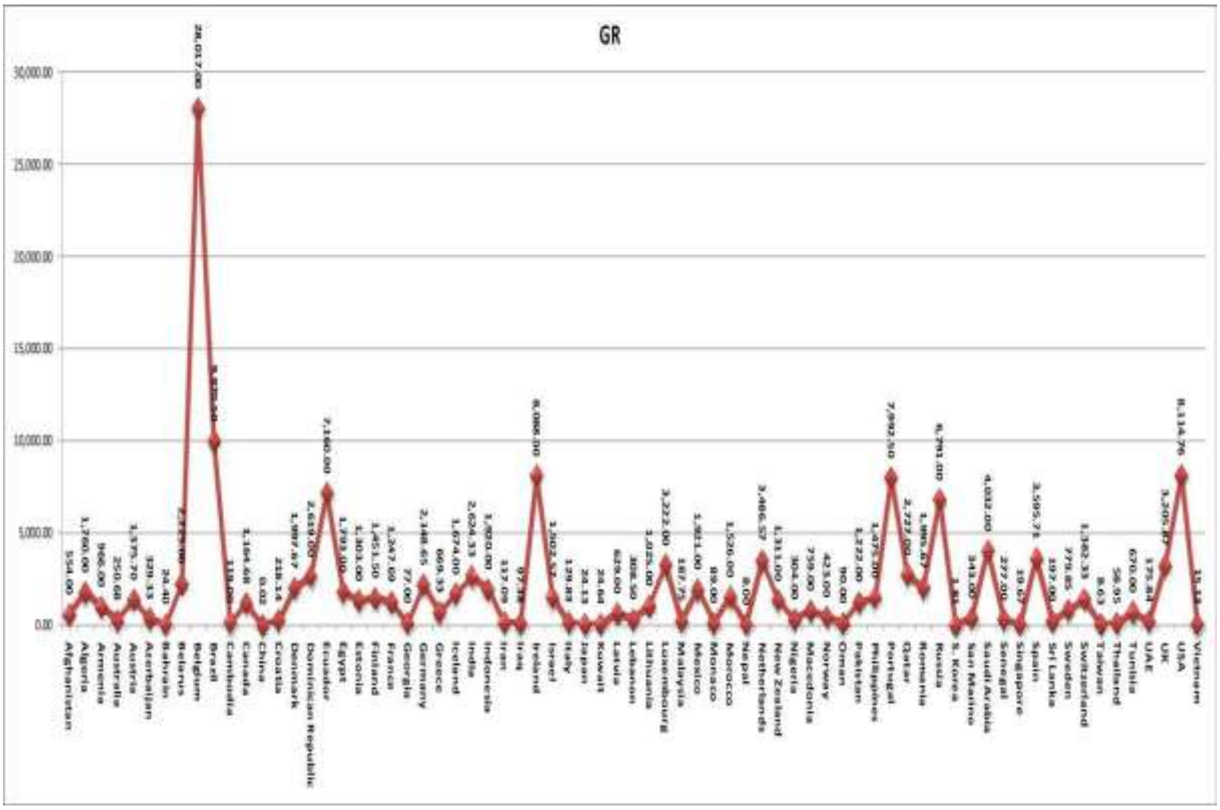

Figure 1. Distribution of GR for Coronavirus

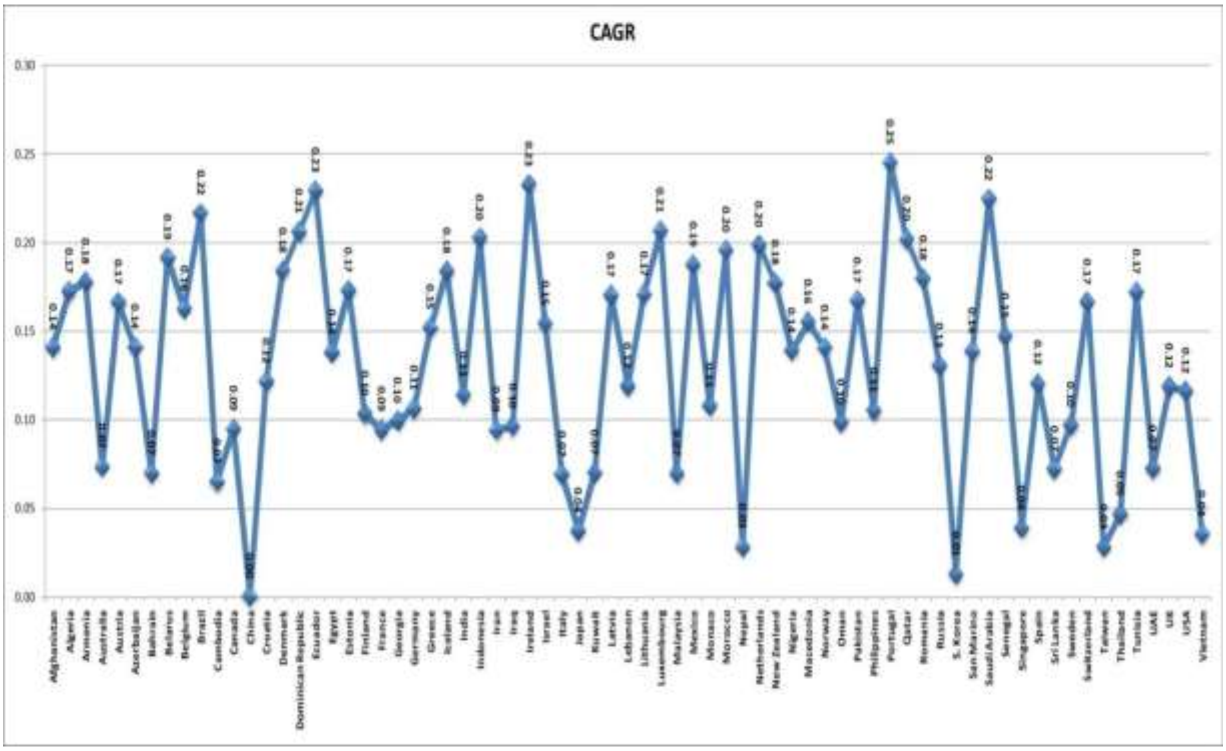

Figure 2. Distribution of CAGR for Coronavirus

Since the disease is transmitted person by person, prevention of the process of transmission is the most important way of control. Preventive education and control avoid the spread of the disease largely. The reduction of Coronavirus growth rates reflects the country's efforts in controlling the transmission chain and the virus. Countries with lower growth rates have provided a better prevention performance. These countries have taken stricter measures to prevent the further dispersion of COVID-19, including closing borders, restricting travels, and taking serious emergency actions.

To prevent the spread of diseases widely, the WHO general recommendations to the general public should be followed to reduce the exposure to the pathogenic microbial factors. To reduce the rate of the virus infection, there must be a reasonable balance in controlling the stress and indifference to the disease, because anxiety lowers the body's immune system. Broadcasting unnecessary information about the Coronavirus leads to the fear and anxiety of people. Fighting with Corona must become the urban and family-centered management that each country's culture plays a major role in this issue. Strengthening the immune system makes it less likely for the disease to be developed. Proper rest, exercise, and a healthy diet are essential to boost the immune system.

Death Rate of Corona patients

In this section, the Death Rate (DR) of Coronavirus patients in the world health units is discussed. The statistical data of the study are from the results of WHO report from 1st March to 11th April 2020. Table 4 presents the DR of Coronavirus by two statistics of death rates in that country and the world.

Table 3. Gross DR of Coronavirus patients (Worldometer)

No.	Country	Total Cases	Total Deaths	Tot Deaths/ 1M pop	Death Rates	Death rate of the Country to all the dead
1	**Afghanistan**	555	18	0.5	0.0324	0.0002
2	**Algeria**	1,761	256	6	0.1454	0.0025
3	**Armenia**	967	13	4	0.0134	0.0001
4	**Australia**	6,292	56	2	0.0089	0.0006
5	**Austria**	13,767	337	37	0.0245	0.0033
6	**Azerbaijan**	991	10	1	0.0101	0.0001
7	**Bahrain**	1,016	6	4	0.0059	0.0001
8	**Belarus**	2,226	23	2	0.0103	0.0002
9	**Belgium**	28,018	3,346	289	0.1194	0.0331
10	**Brazil**	19,943	1,074	5	0.0539	0.0106
11	**Cambodia**	120	-	-	0.0000	0.0000
12	**Canada**	22,148	569	15	0.0257	0.0056
13	**China**	81,953	3,339	2	0.0407	0.0330
14	**Croatia**	1,534	21	5	0.0137	0.0002
15	**Denmark**	5,996	260	45	0.0434	0.0026
16	**Dominican Republic**	2,620	126	12	0.0481	0.0012
17	**Ecuador**	7,161	297	17	0.0415	0.0029
18	**Egypt**	1,794	135	1	0.0753	0.0013
19	**Estonia**	1,304	24	18	0.0184	0.0002
20	**Finland**	2,905	49	9	0.0169	0.0005
21	**France**	124,869	13,197	202	0.1057	0.1304
22	**Georgia**	234	3	0.8	0.0128	0.0000
23	**Germany**	122,530	2,736	33	0.0223	0.0270
24	**Greece**	2,011	92	9	0.0457	0.0009
25	**Iceland**	1,675	7	21	0.0042	0.0001
26	**India**	7,876	249	0.2	0.0316	0.0025
27	**Indonesia**	3,842	327	1	0.0851	0.0032
28	**Iran**	70,029	4,357	52	0.0622	0.0431
29	**Iraq**	1,279	70	2	0.0547	0.0007
30	**Ireland**	8,089	287	58	0.0355	0.0028
31	**Israel**	10,525	96	11	0.0091	0.0009
32	**Italy**	147,577	18,849	312	0.1277	0.1863
33	**Japan**	6,005	99	0.8	0.0165	0.0010
34	**Kuwait**	1,154	1	0.2	0.0009	0.0000
35	**Latvia**	630	3	2	0.0048	0.0000
36	**Lebanon**	619	20	3	0.0323	0.0002
37	**Lithuania**	1,026	23	8	0.0224	0.0002
38	**Luxembourg**	3,223	54	86	0.0168	0.0005
39	**Malaysia**	4,530	73	2	0.0161	0.0007

Table 3. Gross DR of Coronavirus patients (Worldometer) – Continued

No.	Country	Total Cases	Total Deaths	Tot Deaths/ 1M pop	Death Rates	Death rate of the Country to all the dead
40	**Mexico**	3,844	233	2	0.0606	0.0023
41	**Monaco**	90	1	25	0.0111	0.0000
42	**Morocco**	1,527	110	3	0.0720	0.0011
43	**Nepal**	9	-	-	0.0000	0.0000
44	**Netherlands**	24,413	2,643	154	0.1083	0.0261
45	**New Zealand**	1,312	4	0.8	0.0030	0.0000
46	**Nigeria**	305	7	0.03	0.0230	0.0001
47	**Macedonia**	760	34	16	0.0447	0.0003
48	**Norway**	6,360	114	21	0.0179	0.0011
49	**Oman**	546	3	0.6	0.0055	0.0000
50	**Pakistan**	4,892	77	0.3	0.0157	0.0008
51	**Philippines**	4,428	247	2	0.0558	0.0024
52	**Portugal**	15,987	470	46	0.0294	0.0046
53	**Qatar**	2,728	6	2	0.0022	0.0001
54	**Romania**	5,990	282	15	0.0471	0.0028
55	**Russia**	13,584	106	0.7	0.0078	0.0010
56	**S. Korea**	10,480	211	4	0.0201	0.0021
57	**San Marino**	344	34	1,002	0.0988	0.0003
58	**Saudi Arabia**	4,033	52	1	0.0129	0.0005
59	**Senegal**	278	2	0.1	0.0072	0.0000
60	**Singapore**	2,108	7	1	0.0033	0.0001
61	**Spain**	161,852	16,353	350	0.1010	0.1616
62	**Sri Lanka**	198	7	0.3	0.0354	0.0001
63	**Sweden**	10,151	887	88	0.0874	0.0088
64	**Switzerland**	24,900	1,003	116	0.0403	0.0099
65	**Taiwan**	385	6	0.3	0.0156	0.0001
66	**Thailand**	2,518	35	0.5	0.0139	0.0003
67	**Tunisia**	671	25	2	0.0373	0.0002
68	**UAE**	3,360	16	2	0.0048	0.0002
69	**UK**	73,758	8,958	132	0.1215	0.0885
70	**USA**	503,177	18,761	57	0.0373	0.1854
71	**Vietnam**	258	-	-	0.0000	0.0000

The findings in Table 4 indicate that the countries of "Algeria, Italy, UK, Belgium, Netherlands, France, Spain, San Marino, Sweden, and Indonesia" have the highest gross DR for the Coronavirus, respectively. The largest share of gross DR of patients in the world happened in the countries of "Italy, USA, Spain, France, UK, Iran, Belgium, China, Germany, and Netherlands ", respectively.

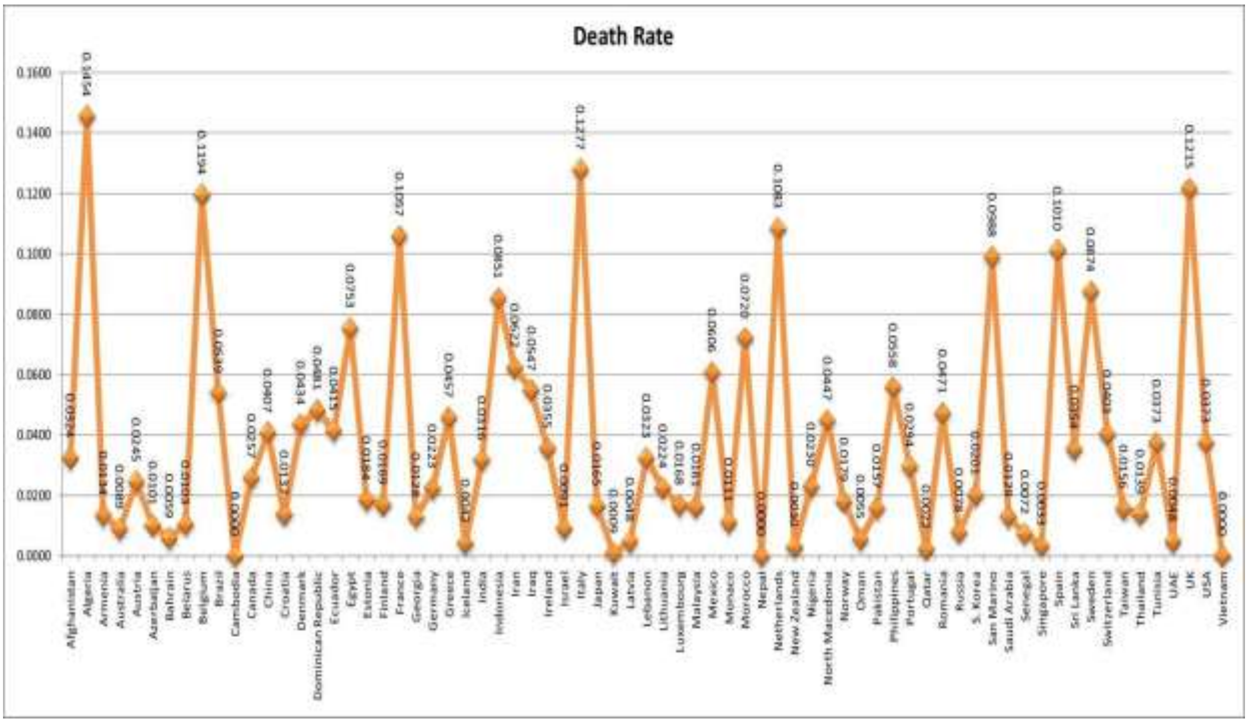

Figure 3. Distribution of gross DR for Coronavirus patients

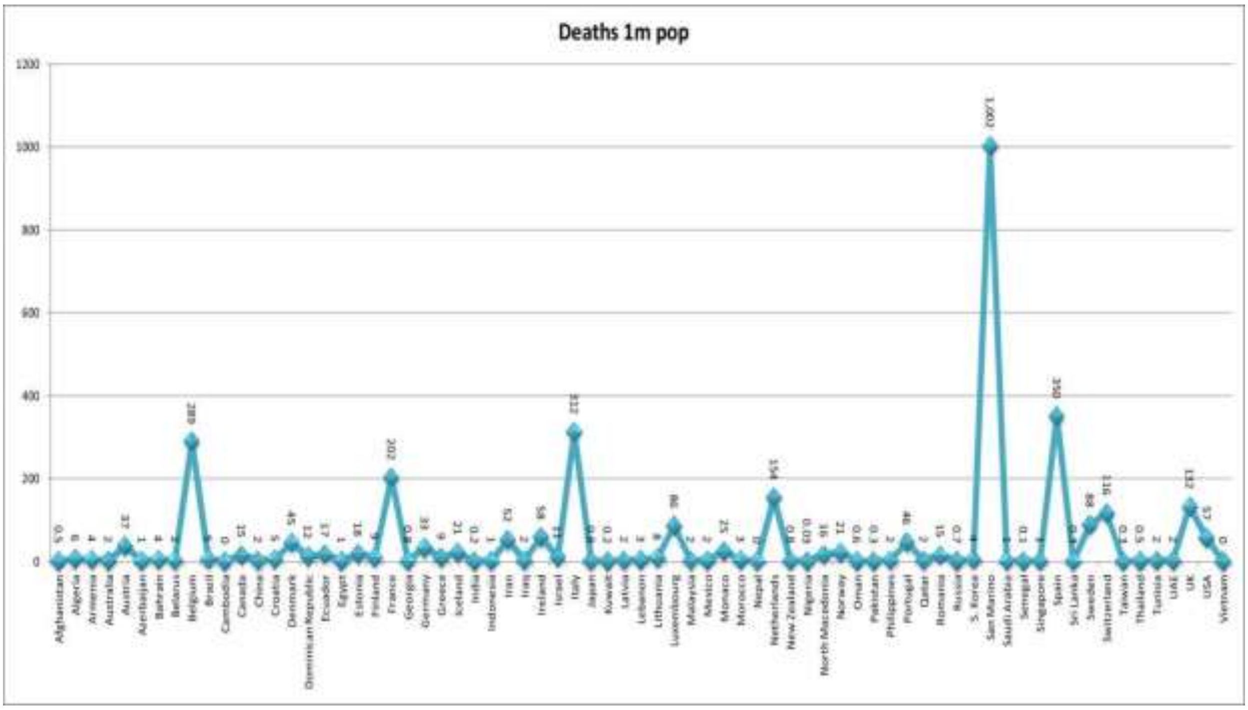

Figure 4. Distribution of gross DR for Coronavirus patients (1 M pop)

The highest DR (1M pop) is in the countries of "San Marino, Spain, Italy, Belgium, France, Netherlands, UK, Switzerland, Sweden, and Luxembourg". Figure 4 shows the distribution of DR (1M pop) of Coronavirus patients.

Since death has natural, social, cultural, economic and environmental aspects, so its study is important, both demographically and in other respects. But this requires access to reliable statistical sources. The death rate is a statistical measure that represents the number of deaths occurring in a given population and is calculated as the ratio of death to the population. This indicates the overall death levels of a community or society as a whole, but its application is limited since it does not consider the age distribution of the population. Thus, even if the general death rate of the two regions is the same, the age of death is not known at that age. In other words, the proportion of deaths to the population varies across the countries, according to their climatic, health, food, social and economic situations. The death table reflects the social and economic situation of society. Thus, by comparing it at different times and places, information on the health and living standards of individuals can be derived which is useful in many planning centers. However, it should be noted that the small difference in death rates does not reflect similar health status in these two places of the world and this is due to the age structure of these two populations. The very young population in countries naturally reduces the death rate in the whole population while in countries where the proportion of young people is low and the proportion of elderly is high, the death rate increases.

In developing countries, unhealthy living conditions and malnutrition are also contributing to the severe damage caused by infectious diseases, which have a major role in deaths. The type of diseases caused by new infectious factors may depend on geographical location and environmental and climatic conditions. Changing the environment is also effective in causing disease because there would be new carriers who have no previous resistance against the virus.

Death, on the one hand, can be due to the acute and urgent nature of infectious diseases and on the other hand, it may be due to complications from the disease itself or underlying diseases. Worldometer data showed that underlying diseases such as "Cancer, Hypertension, Acute respiratory disease, Diabetes, Cardiovascular disease" had an impact on mortality.

This study highlights the importance of developing the ability to detect and evaluate the severity of each country's health hazards. It also shows how infectious diseases are responsible for the dominant share of deaths which can be controlled and reduced by WHO by implementing and enforcing scientific and executive policies and strategies. This will indeed be enormous social, economic and health benefits in terms of cost-effectiveness. Governments, therefore, focus and manage WHO's recommended measures of risk prevention and mitigation in their sovereign and supervisory role in ensuring the health, mitigating inequalities and sustaining development. Additionally, it is recommended that countries' voluntary assistance to others should be spent by the WHO on key health interventions, including epidemic control and death reduction, effective support for medical technologies, and determinants of crisis health systems.

Recovery rate of Coronavirus patients

In this section, the Recovery Rate (RR) of Coronavirus patients in the world health units is presented. The statistical data of the study are from the results of the WHO report from 1st March to 11th April 2020. To determine the RR, the ratio of recovered patients to affected patients is used. The results are presented in Table 5.

Table 4. RR of Coronavirus patients

No.	Country	Total Cases	Total Recovered	Recovery Rate
1	**Afghanistan**	555	32	0.0577
2	**Algeria**	1,761	405	0.2300
3	**Armenia**	967	173	0.1789
4	**Australia**	6,292	3,265	0.5189
5	**Austria**	13,767	6,604	0.4797
6	**Azerbaijan**	991	159	0.1604
7	**Bahrain**	1,016	551	0.5423
8	**Belarus**	2,226	172	0.0773
9	**Belgium**	28,018	5,986	0.2136
10	**Brazil**	19,943	173	0.0087
11	**Cambodia**	120	75	0.6250
12	**Canada**	22,148	6,013	0.2715
13	**China**	81,953	77,525	0.9460
14	**Croatia**	1,534	323	0.2106
15	**Denmark**	5,996	1,955	0.3261
16	**Dominican Republic**	2,620	98	0.0374
17	**Ecuador**	7,161	368	0.0514
18	**Egypt**	1,794	384	0.2140
19	**Estonia**	1,304	93	0.0713
20	**Finland**	2,905	300	0.1033
21	**France**	124,869	24,932	0.1997
22	**Georgia**	234	56	0.2393
23	**Germany**	122,530	53,913	0.4400
24	**Greece**	2,011	269	0.1338
25	**Iceland**	1,675	751	0.4484
26	**India**	7,876	774	0.0983
27	**Indonesia**	3,842	286	0.0744
28	**Iran**	70,029	41,947	0.5990
29	**Iraq**	1,279	550	0.4300
30	**Ireland**	8,089	25	0.0031
31	**Israel**	10,525	1,258	0.1195
32	**Italy**	147,577	30,455	0.2064
33	**Japan**	6,005	762	0.1269
34	**Kuwait**	1,154	133	0.1153
35	**Latvia**	630	16	0.0254

Table 4. RR of Coronavirus patients) – Continued

No.	Country	Total Cases	Total Recovered	Recovery Rate
36	**Lebanon**	619	76	0.1228
37	**Lithuania**	1,026	54	0.0526
38	**Luxembourg**	3,223	500	0.1551
39	**Malaysia**	4,530	1,995	0.4404
40	**Mexico**	3,844	633	0.1647
41	**Monaco**	90	5	0.0556
42	**Morocco**	1,527	141	0.0923
43	**Nepal**	9	1	0.1111
44	**Netherlands**	24,413	250	0.0102
45	**New Zealand**	1,312	422	0.3216
46	**Nigeria**	305	58	0.1902
47	**Macedonia**	760	41	0.0539
48	**Norway**	6,360	32	0.0050
49	**Oman**	546	109	0.1996
50	**Pakistan**	4,892	762	0.1558
51	**Philippines**	4,428	157	0.0355
52	**Portugal**	15,987	266	0.0166
53	**Qatar**	2,728	247	0.0905
54	**Romania**	5,990	758	0.1265
55	**Russia**	13,584	1,045	0.0769
56	**S. Korea**	10,480	7,243	0.6911
57	**San Marino**	344	50	0.1453
58	**Saudi Arabia**	4,033	720	0.1785
59	**Senegal**	278	152	0.5468
60	**Singapore**	2,108	492	0.2334
61	**Spain**	161,852	59,109	0.3652
62	**Sri Lanka**	198	54	0.2727
63	**Sweden**	10,151	381	0.0375
64	**Switzerland**	24,900	11,100	0.4458
65	**Taiwan**	385	99	0.2571
66	**Thailand**	2,518	1,135	0.4508
67	**Tunisia**	671	43	0.0641
68	**UAE**	3,360	418	0.1244
69	**UK**	73,758	344	0.0047
70	**USA**	503,177	27,314	0.0543
71	**Vietnam**	258	144	0.5581

The number of infected people in each country is proportional to the extent of its involvement in the virus. United States is the country with the highest outbreak of the disease with 503177 cases, followed by Spain, Italy, France, Germany, China, UK, Iran, Belgium, and Switzerland, respectively. Some countries have been able to reduce the number of people who are infected daily, and some countries continue to see an increase. Over time, some countries have been able to reduce the number of people who are infected daily, and some countries continue to experience an increase. According to the estimated RR in Table 5, " China, S. Korea, Cambodia, Iran, Vietnam, Senegal, Bahrain, Australia, Austria, Thailand'' have the highest percentages of RR in the world, respectively. Figure 5 shows the distribution of RR for Coronavirus patients.

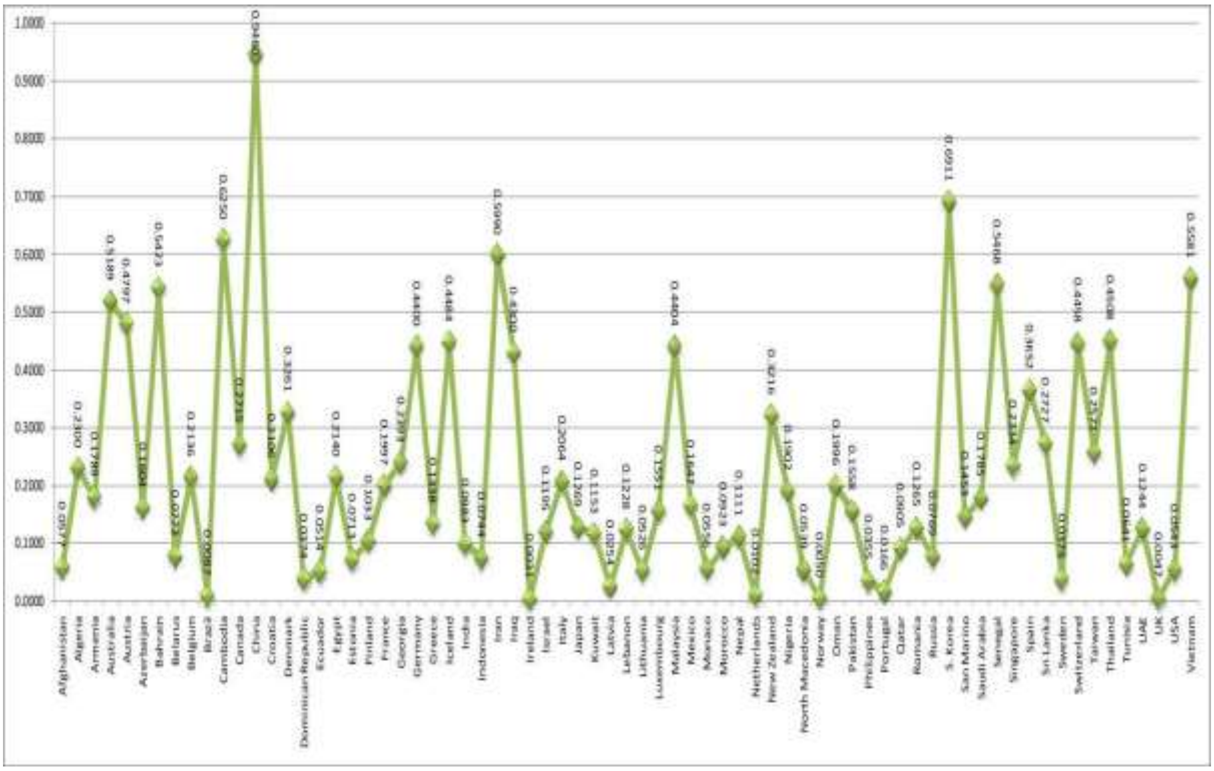

Figure 5. Distribution of RR for Coronavirus patients

Disease recovery is one of the most important factors affecting the quality of health care in all countries of the world. Successful treatment of patients, in addition to the professional competence of medical staff, also depends on a range of factors such as timely diagnosis, quality of care, modern and advanced equipment, training and knowledge of medical staff, health care budget and health center self-management of the health system unit.

Patient awareness is also effective in treatment. According to the Health Belief Model, people's attitudes and beliefs have a significant impact on their health behaviors. Hence, the key elements of these beliefs are perceived benefits and barriers of health care. Accordingly, people respond appropriately to health messages and disease prevention when they feel that changing behavior leads to a great benefit for them. Health behaviors of individuals are largely rooted in social and cultural contexts (Heydan, 2009).

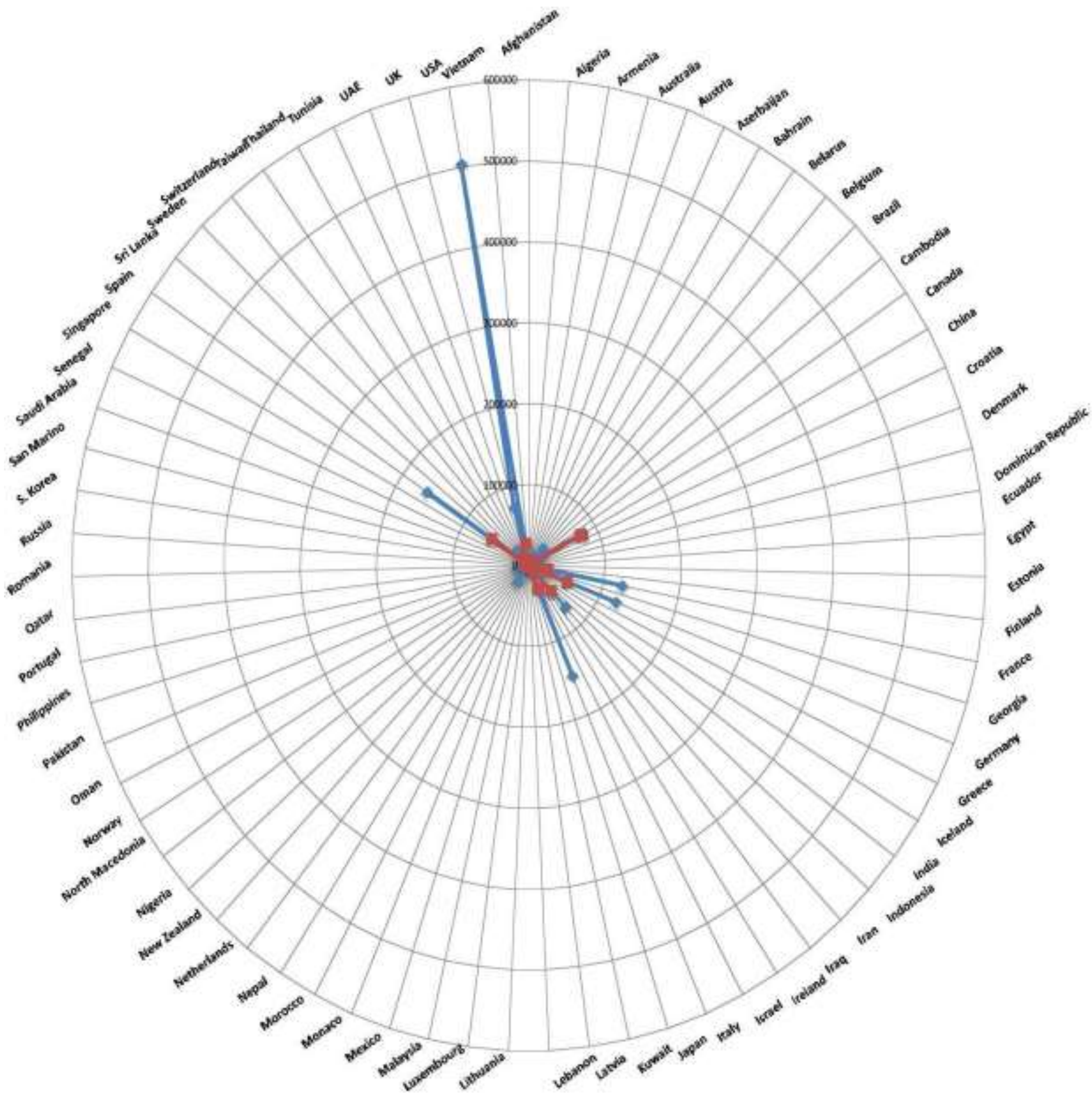

Figure 6. Chart of ■recovered and ■infected people

Importance-Performance Analysis (IPA), by evaluating customer satisfaction and its findings, provides valuable information in order to take appropriate action to improve the quality of care according to the customers' expectations. By determining the importance average and perceptions (performance) average of each dimension, the two-dimensional matrix is presented including x-axis (number of recovered) and y-axis (number of patients). The analysis is done regarding the position of the dimensions in the areas of this matrix. Figure 7 presents an IPA chart showing the position of health care quality in studied units for recovered patients of Coronavirus. Based on the importance and performance of health system units, the studied units can be distinguished in the following four areas:

X>5311.70 & Y<22620.28	**X<5311.70 & Y<22620.28**	**X>5311.70 & Y>22620.28**	**X<5311.70 & Y>22620.28**
Waste area: Austria, Canada, S. Korea	**Indifference area: Other health system units**	Acceptable area: China, France, Germany, Iran,،Italy، Spain, Switzerland, USA	Focus area: UK, Netherlands,

Apparently, the health system units of focus areas have been to the waste area, indicating that patients are not satisfied with the performance of the health systems in these countries. Health services of this area are vulnerable and should be prioritized for improvement. Patients of health system units in the acceptable areas are currently satisfied and the continuation of the current strategy is recommended. Service processes of this area are maintained and considered as competitive advantages.

Efficiency evaluation of health system units

Based on the data in Table 1 and the implementation of the BCC model in DEAFrontier software, the research findings are presented in Table 6. The optimal using rate of the resources is shown by the efficiency percentage. According to the results of the software presented in Table 6, the efficiency of health system units in optimizing the use of resources is determined.

SPSS software is used to investigate the relationship between the input indices on the performance of the health system unit. According to Table 6, there is a significant relationship between two variables at a 99% confidence level where the value of significant value (sig) is less than 0.01, and at the 95% level for the sig less than 0.05. Since the correlation coefficients of the variables are both positive, increasing the values of "Total Cases, Day of Infection, Population, Total Deaths, and Total Recovered" leads to an increase in the performance of the health system. On the other hand, there is no significant relationship between "GDP Per Capita" and other indices.

Table 6. Results of SPSS software for the relationship between the indices

Indices	Significant Value)Sig(	Pearson Correlation Coefficient
Total Cases	0.000	0.700"
Total Deaths	0.023	0.335'
Day of Infection	0.000	0.503"
Population	0.002	0.450"
Total Recovered	0.000	0.700"
GDP Per Capita	0.563	0.087
Tourism	0.571	0.076

Of the non-zero data from 68 of the 71 countries in "Total Cases, Day of Infection, Total Recovered, Total Deaths, Population", 52 health systems units are in adverse condition. Based on the calculations, 16 health system units are identified as efficient. An efficient health system unit represents an improvement of health services, continuous improvement of quality of health services through proper management, efficiency of health centers and optimal utilization of human resources and capacities as well as serious follow up of specialized training courses for health care staff and support.

Table 7. Efficiency of the health system unit by DEAFrontier

Efficient Unit

DMU Name	Efficiency	Benchmarks			
Afghanistan	11.13458	0.003	China		
Algeria	3.84485	0.018	China		
Armenia	2.79978	0.506	Bahrain		
Australia	1.27838	0.534 0.166	Bahrain Monaco	0.075 0.757	Kuwait Senegal
Austria	1.05011	0.623 0.973	Iceland Senegal	0.009	Monaco
Azerbaijan	3.63694	0.004 0.004	China Iran	0.380 0.110	Georgia Tunisia
Bahrain	1.00000				
Belarus	7.54418	0.003 0.303	China Switzerland	0.074	Iran
Belgium	2.12146	0.034 0.005 0.051	Iran Iran Tunisia	0.867 0.073	Georgia Kuwait
Brazil	91.55614	0.456	Bahrain		
Canada	2.24747	0.449 0.025 0.051	Bahrain Iran Tunisia	0.893 0.028	Georgia Kuwait
China	1.00000				
Croatia	2.77335	0.890 0.102 0.219	Bahrain Iran Tunisia	0.138 0.085	China S. Korea
Denmark	1.72645	0.101 0.283	Bahrain S. Korea	0.267	Iran
Dominican Republic	16.63912	0.749 0.051	Bahrain S. Korea	0.001 0.058	Iran Tunisia
Ecuador	11.92042	0.433 0.064	Bahrain Iran	0.834	Iceland
Egypt	4.17666	0.020 0.011 0.175	China Iran Tunisia	0.004 0.062	China S. Korea
Estonia	6.10185	0.400 0.230	Bahrain S. Korea	0.059 0.278	Iran Tunisia
Finland	5.76030	0.935 0.476	Bahrain Senegal	0.504	Monaco
France	2.10907	0.180 0.124 0.025	Germany Kuwait Tunisia	0.438 0.013	Iceland San Marino
Georgia	1.00000				
Germany	1.00000				
Greece	4.82592	0.816	Bahrain		
Iceland	1.00000				
India	9.53222	0.095 0.078	China S. Korea	0.004 0.102	China Tunisia
Indonesia	12.24583	0.043	China		
Iran	1.00000				
Iraq	2.00328	0.012 0.054	China Tunisia	0.903	Senegal
Ireland	139.49599	0.184	Iceland		
Israel	4.46917	0.787 0.938	Iceland Senegal	0.049	Monaco
Italy	1.87715	0.001 0.456 0.084	China Kuwait Tunisia	0.007 0.269	Iran Switzerland
Japan	7.32333	0.070 0.127	China Switzerland	0.086	Iran
Kuwait	1.00000				
Latvia	1.15809	0.131 0.832	Georgia Senegal	0.098	Monaco
Lebanon	4.75561	0.242	Bahrain		

Table 7. The efficiency of health system unit by DEAFrontier – Continued

■ Efficient Unit

DMU Name	Efficiency	Benchmarks			
Lithuania	8.06113	0.508 0.430	Bahrain San Marino	0.325 0.113	Kuwait Tunisia
Luxembourg	2.18304	0.967 0.756	Iceland Georgia	0.002	China
Malaysia	1.08153	0.901 0.003 0.074	Iceland Iran Tunisia	0.229 0.187	Georgia Kuwait
Mexico	4.50883	0.817 0.027	Bahrain Tunisia	0.006	Spain
Monaco	1.00000				
Morocco	1.00000				
Netherlands	58.12061	0.382	Bahrain		
New Zealand	1.96402	0.009	China		
Nigeria	1.80885	0.001 0.336	China Iran	0.282	Iceland
North Macedonia	15.50088	0.008 0.001 0.042	China Iran Tunisia	0.687 0.260	Georgia Kuwait
Norway	82.52260	0.046 0.005	Iceland Senegal	0.951 0.044	Georgia Tunisia
Oman	1.43771	0.000 0.126	China Senegal	0.866	Monaco
Pakistan	5.96340	0.058 0.716 0.035	China Kuwait Tunisia	0.008 0.195	Iran Switzerland
Philippines	26.04322	0.051 0.223	China Kuwait	0.770 0.007	Georgia S. Korea
Portugal	30.01400	0.428 0.262	Iceland Senegal	0.680	Monaco
Qatar	3.59039	0.365 0.776	Iceland Senegal	0.173	Monaco
Romania	4.97857	0.376 0.379	Bahrain Switzerland	0.082 0.111	Iran Tunisia
Russia	10.46437	0.046 0.008 0.078	Bahrain Spain Tunisia	0.543 0.006	Kuwait Switzerland
S. Korea	1.00000				
San Marino	1.00000				
Saudi Arabia	4.07524	0.498	Bahrain		
Senegal	1.00000				
Singapore	2.36496	0.086 0.187	Bahrain S. Korea	0.017 0.298	China Tunisia
Spain	1.00000				
Sri Lanka	1.00000				
Sweden	15.11682	0.858	Iceland		
Switzerland	1.00000				
Taiwan	2.57465	0.001 0.027	China Switzerland	0.115	Iran
Thailand	2.00699	0.028	China		
Tunisia	1.00000				
UAE	4.76073	0.004 0.846	China Senegal	0.126	Monaco
UK	36.66778	0.797	Iceland		
USA	2.16517	0.015 0.040 0.119	China Iran Tunisia	0.817 0.020	Georgia Kuwait

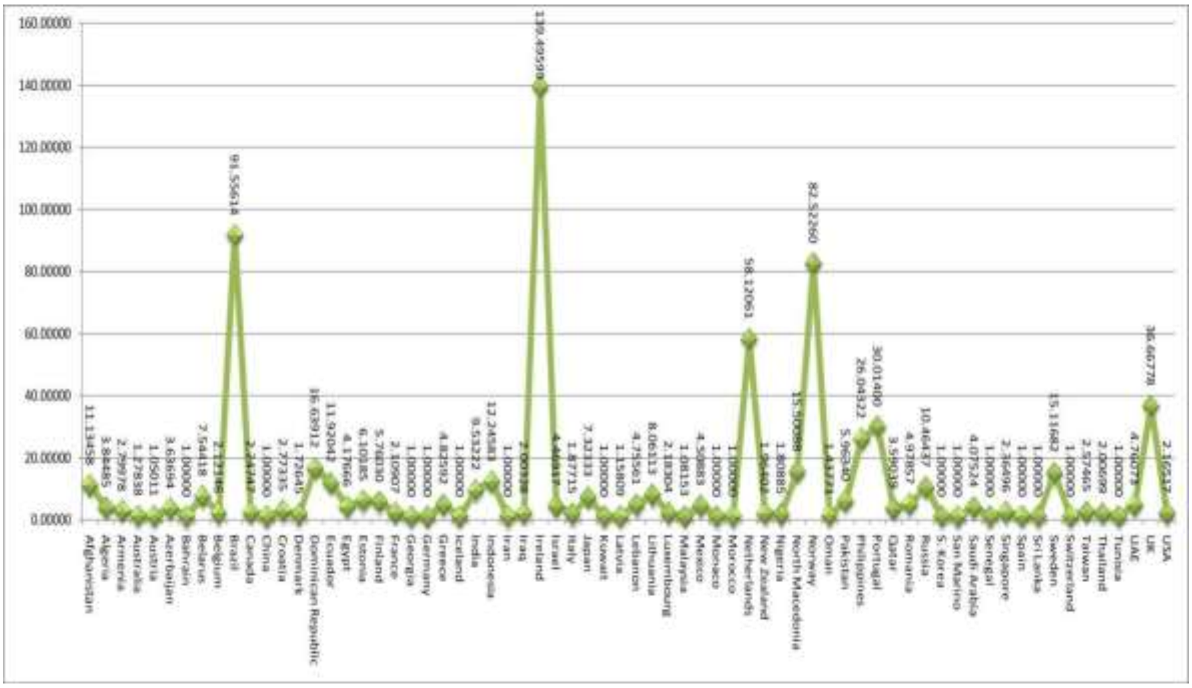

Figure 7. Distribution of efficiency for health system unit worldwide

As a result of the model implementation, 52 units of health systems are inefficient. A reference health unit is specified for the inefficient health system units to increase their efficiency. Also, the amount of input change from the inefficient health unit to the reference health unit is determined. For example, to become an efficient Health System unit, Nigeria Health System Unit has to change its input 0.001 similar to China Health System Unit, or 0.282 similar to Iceland Health System Unit, or 0.336 similar to Iran Health System Unit.

The efficiency difference between health system units is due to the composition method, use of inputs and the amount of output. Often, the health system units with less efficiency have a high using rate, but it is not proportional to the output. Efficiency shows the optimal use of resources. In this section, the results of the data envelopment analysis model have been presented for the health units of different countries. Input and output factors cannot have a direct effect on efficiency alone. The effect of all factors together shows the health condition of the countries.

5. Discussion and conclusion

DEA is more generalizable than other methods of performance evaluation. This method is an alternative for regression. If the units have multiple inputs and outputs, the econometric method cannot appropriately evaluate the efficiency of these units. The purpose of DEA is to determine the efficiency of a decision-making system or unit through the process of converting input to output. In other words, the goal is to identify the units that get the most output from the lowest input. The present study aims to measure the efficiency of the world health system in crisis management of Corona virus in 2020.

In this study, the efficiency scores of the health system unit of 71 countries involved in Coronavirus were calculated by parametric and nonparametric statistical tests. Evaluating the performance of health system units leads to the improvement of performance, increase of efficiency, dramatic reduction of input usage, and consequent reduction of costs and waste. In order to reduce the potential impacts of inefficient health system units, the performance of the health system unit should be improved and promoted. Benchmarking of efficient health system units is one of the best practices and working processes to improve health system performance. The efficiency difference between health system units is due to the composition method, use of inputs and the amount of output. Often, the health system units with less efficiency have a high using rate, but it is not proportional to the output. Efficiency shows the optimal use of resources. The main purpose of this study was to model the performance of efficient health system units to reduce the mortality and morbidity of Coronavirus.

The most important problems of the health system units to deal with crises are the weakness of crisis committee activity, lack of a system for organizing medical staff, lack of training courses, lack of new technologies, lack of human resources and medical equipment. Proper crisis management will be achieved through well-planned crisis management, necessary internal and external crisis coordination in the organization especially with the use of new technologies, identification of capabilities to respond to the crises by proper reinforcing and organizing the human resources, and providing the necessary training. Proper planning plays a major role in the use of resources, training, prevention, the cultural promotion of prevention of the virus spread, and reducing the costs and resources of health system units. Inefficient health system units can diagnose their weaknesses and use the experiences of efficient units to maintain and improve their performance. Also, more appropriate management of resources can make them an efficient unit. In determining the performance of health system units, limited data (inputs and outputs) are evaluated. Considering other effective indices could be a better criterion for evaluating health system units in the world, which is recommended for future research. Based on the results of the research, the following results can be discussed:

- The infection rates are lowest in the countries of “China, S. Korea, Nepal, Taiwan, Vietnam, Singapore, Japan, Bahrain, Kuwait, and Thailand”, respectively. These countries have taken stricter measures to prevent the further dispersion of COVID-19, including closing borders, restricting travels, and taking serious emergency actions. On the other hand, the low infection rate may also be due to the low tourist traffic of that country. Health behaviors are largely rooted in social and cultural contexts
- The countries of "Cambodia, Nepal, Vietnam, Kuwait, Qatar, New Zealand, Singapore, Iceland, UAE, and Latvia” recorded the lowest Death Rates, respectively, for the Coronavirus. DR is the reflection of the socio-economic conditions of society and the people's health conditions and living standards. On the other side, DR depends on geographical location and environmental and climatic conditions, underlying disease and the age of the population.
- Ten countries of "China, S. Korea, Cambodia, Iran, Vietnam, Senegal, Bahrain, Australia, Austria, and Thailand’’ have the highest percentages of RR in the world, respectively. Successful treatment of patients, in addition to the professional competence of medical staff, also depends on a range of factors such as timely diagnosis, quality of care, modern and advanced equipment, training and knowledge of medical staff, health care budget and health center self-management of the health system unit.
- According to the result of data envelopment analysis, countries of Afghanistan, Bahrain, China, Georgia, Germany, Iceland, Iran, Kuwait, Monaco, Morocco, S. Korea, San Marino, Senegal, Spain, Sri Lanka, Switzerland, and Tunisia are efficient. The efficiency difference between health system units is due to the composition method, use of inputs and the amount of output. Often, the health system units with less efficiency have a high using rate, but it is not proportional to the output. Efficiency shows the optimal use of resources. Based on the calculations, 16 health system units are identified as efficient. A comparison between efficient

countries is also important and can be a planning guide for the countries. Efficient countries have used their capacity more favorably than other countries. They also have an acceptable feasibility in the health system.

- So far, a wide variety of treatments for corona crisis have been evaluated. There is no specific method for treating this disease, and no drug has been introduced for its definitive treatment up to now. In the crisis of such diseases, in addition to treatment, it should be considered as a problem for psychiatrists and psychologists. Because the behavioral characteristics of patients and the infected community damage the health and recovery process seriously. So, it is recommended to establish an organizational system for crisis management along with planning, optimal use of resources, use of necessary expertise, training and government support.
- To gain better results, the strategy to increase the efficiency of health system units should be used at four levels of the Ministry of Health, University of Medical Sciences, Health Services and Health System Units. The Ministry of Health should improve the efficiency of the health system units by reforming the health system, developing the primary health care network, reforming the tariff on health services, distributing medical resources optimally and giving more authority to the universities of sports sciences.
- Dispersion in the provision of health services leads to inefficient allocation of health resources and affects the quality, cost and health outcomes adversely. Providing integrated health services should be one of the goals of the health system. Employing global information management systems will lead to increase of efficiency and proper management.
- Financial reforms in the health system must be accompanied with the reforms in the provision of health services to achieve efficient results. Increasing the budget of health system without interventions to coordinate and control the supply of health services leads to the waste of resources.
- Anyway, the ultimate goal is to provide services to the clients and accelerate the process of improving the physical and mental condition of patients. The requirement to achieve this goal is summarized in the factors of healthy human resources in terms of physical and mental health along with the required equipment with the necessary quantity and excellent quality, as well as sufficient financial resources. Improvement of hospital spaces is recommended with an environmental healing approach (healing garden), allopathic medicine and ergonomic knowledge. Allopathic treatment is a system that seeks to treat a disease with different conditions. The healing garden comes from the word HEAL, which means improving the physical condition, improving the disease, getting rid of some bad conditions and health.

Given the high mortality rate of Coronavirus infections, this should be considered a serious global health problem. Therefore, appropriate WHO intervention programs are needed to prevent and minimize the infection rate of viruses and evaluate the prevention programs periodically. Part of the high mortality rate may be due to the lack of use of life expectancy rates that vary across countries but they have been considered identical. Also, another part may be related to differences in the medical context and facilities.

Despite the advances of various medical sciences in the treatment and control of contagious diseases, the introduction and description of the background of common infectious diseases undoubtedly help to understand the epidemiological status of the diseases. In this context, codifying a protocol is recommended by an international observer such as the WHO, which can improve the quality of care in health centers during a crisis. Crisis protocols are a valuable tool.

Managerial Insights

The health system units, by including huge and complex resources, are currently one of the most important centers in the world for potential and unexpected events (both inside the hospital and outside the hospital). This increases the need to examine the various challenges of providing the best crisis management methods. One of the main problems that hospitals face in terms of unexpected events, is the lack of proper planning and organization by the hospital manager. This results in problems to deal with the accidents, hospital preparation, and training of staff to control the crisis. So, presenting a crisis management plan in the hospital is vital due to the inability of patients, the existence of expensive and sensitive devices, the existence of hazardous and risky materials, and the heterogeneity of employees.
In the current situation, the health system units which have weaknesses in their economic and managerial structure, are not capable of facing the crisis by using all of their resources. Therefore, it will be necessary to establish a responsive system to solve the problems of hospitals, which leads to a successful crisis management. In addition, it is recommended that:
Principles of crisis management program design should be developed in the form of regulations and executive instructions taking into account the situation of each hospital. Also, the approach of dealing with crisis management programs should be operationalized and considered as one of the main strategies of the World Health Organization. Because planning and focusing on crisis management programs will solve other current hospital problems.

Research limitation

- Research findings are limited to the duration of data collection. Increasing or decreasing the number of units in the health system is also one of the limitations of the research because by changing the research community the results will change.
- The lack of more effective indicators to evaluate performance is the limitation of this study.
- This method is merely a mathematical method based on linear programming and is not able to compare the qualitative variables of decision units.

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